

Closeout Presentation

Director's Progress Review of the Short Baseline Neutrino Program

December 15-17, 2015

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Table of Contents

Executive Summary	5
1.0 Introduction	5
2.0 Technical Systems	7
2.1 Facilities and Infrastructure	7
2.2 Detectors	10
2.3 Booster Neutrino Beam Upgrade.....	18
3.0 Project Management.....	21
3.1 Cost and Schedule.....	21
3.2 ESH.....	25
3.3 Management	28
4.0 Appendices	31
Charge	32
Agenda	33
Review Committee Contact List and Writing Assignments	36

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Executive Summary

A Director's Progress Review of the Short Baseline Neutrino (SBN) Program was held on December 15-17, 2015 at the Fermilab. The SBN Program is a staged campaign to install and operate three LArTPC detectors in the Booster Neutrino Beam (BNB) to search for sterile neutrinos and develop LAr detector technology for future experiments, especially DUNE. It is a Fermilab hosted program which also includes significant in-kind contributions from several European and American organizations. This review covers the design, construction, installation and commissioning of two of the three detectors: ICARUS and SBND. ICARUS is an existing detector which has run successfully for several years in the Gran Sasso Laboratory, and is now being refurbished at CERN using INFN and CERN resources. SBND is a new detector being built by a collaboration of American and European groups. Conventional and technical infrastructure to support the detectors is being provided mainly by Fermilab and CERN. A conceptual design for a possible upgrade to the Booster Neutrino Beam (BNB) is being developed.

The purpose of the review is to assess the progress and plans for execution of SBN Program, covering cost, schedule, management, ES&H and technical aspects. SBN is a program, not a DOE 413 project and includes significant components provided by non-DOE-funded sources. Nonetheless, it is managed and is evaluated according to standard project management practices.

Overall, the committee found that the SBN Program is well conceived, well managed, and is proceeding satisfactorily toward timely completion and installation of the two detectors. The broad collaboration in the SBN Program is an encouraging example of the international participation, which is so important to the Fermilab Neutrino Program. The ICARUS collaboration is highly experienced and refurbishment of ICARUS is proceeding well, with delivery to Fermilab expected in the second half of 2016. The SBND collaboration benefits from the experience of building MicroBooNE. The design of SBND is proceeding well and construction of its components will begin in 2016. Construction of the two new buildings to house ICARUS and SBND is well along. The overall SBN Program is managed by a capable coordination team based at Fermilab. Coordination of efforts between the two detectors in a number of areas, e.g. the phototube systems, is notable. The proposed upgrade to the BNB could extend the science reach of the SBN program substantially, and a complete conceptual design and corresponding cost and schedule estimate will be completed within the next half year.

A number of significant challenges exist, however. The three SBN detectors, ICARUS, MicroBooNE and SBND, are the responsibilities of three independent collaborations, which adds complexity to the coordination of the construction effort. The successful completion of the SBN detectors and supporting infrastructure requires coordinated design and construction activities by many institutions supported by several different funding agencies, and with many complex interfaces that must be correctly managed. Although the design of the SBND is based on understood design elements developed by ICARUS and subsequent LArTPC detectors, it is a wholly new design. The schedule goal of completing SBND, ready for cold commissioning by July 2018 is very aggressive. Agreed-upon solutions for the design and funding for construction of the cosmic ray tagging system for ICARUS, an essential component for doing the science, are not yet in place. Installation and integration planning for ICARUS at Fermilab is only just starting. Close coordination and good cooperation among all of the parties will be required to successfully meet the challenges of completing this program. This report includes a number of comments and recommendations, which, if followed, should help ensure the success of this program.

The review committee commends the SBN program team for the good progress made so far, and looks forward to a successful completion of the construction and a successful scientific program that it will enable.

Introduction

A Director's Progress Review of the Short Baseline Neutrino (SBN) Program was held on December 15-17, 2015 at the Fermilab. The focus of this review was to assess the cost, schedule, management, ES&H and technical readiness for the execution of the SBN Program.

2.0 Technical Systems

2.1 Facilities and Infrastructure

Subcommittee Lead: Jim Grudzinski

Subcommittee Members: Mark Messier, Brian Rebel, Bill Soyars

Charge Questions:

- Have performance requirements been defined that meet the goals of the SBN program?

Yes

- Have independent design reviews been conducted? Based on the design reviews, are the designs sound and likely to meet the performance requirements?

Several reviews of the facility and infrastructure subsystems were referenced during the breakout sessions. The committee feels that establishing a consistent design review process would benefit the complex nature and aggressive schedule of this project. In particular this will benefit the integration and installation activities. Do the designs capture the entire scope and are they adequately defined?

- Do the designs capture the entire scope and are they adequately defined?

We believe the designs and scope for the facilities and infrastructure will meet the needs of SBND and ICARUS.

- Have the partnering agencies/organizations (e.g. CERN, DOE, INFN, NSF, Switzerland, and STFC) identified and agreed to their respective scope?

There is broad agreement between the agencies as to the scope of the program which each will deliver. The WA104 agreement details the relative responsibilities between CERN and INFN. The details of the interface between FNAL and ICARUS collaboration with respect to the acceptance and installation of the ICARUS detector should be formalized in an MOU.

There is an MOU between FNAL and CERN regarding the Design, Fabrication, Installation and Testing of the SBND Membrane Cryostat.

Findings

- The planning for the facilities and infrastructure is well advanced and the requirements are defined.
- The building design is complete and the construction of the far detector site has begun. Both buildings have been independently reviewed for design and safety.
- The scope of the cryogenic activities by each stakeholder are well-defined and understood.

Closeout Presentation

- Requirements for the cryogenics have been generated based on the physics requirements.
- The facility is designed for maximum overburden of 2.8m for the far and near detectors.
- There are components that are not listed in ASME B31.3 that require validation. There is awareness of this fact within the collaboration.
- The electron lifetime requirement for the SBND is 3ms while the electron lifetime requirement for ICARUS is 15ms.
- **FNAL and CERN use multiple document management systems for the SBND and ICARUS activities.**
- The cosmic ray shielding blocks include blocks reclaimed from FNAL.
- The approach for satisfying the Fermilab ESH requirements for the operation of the ICARUS cryostat have not been finalized. Specifically, the applicable vacuum vessel and low pressure vessel code requirements have not been formalized.
- Final design reviews have been conducted for the SBND and Far Detector buildings. Independent Technical Assessments have been conducted for the Cryostats and Cryogenics for both the near and the far detector.

Comments

- The cosmic ray working group should establish a clear physics requirement for the minimum overburden for each site. This may be useful in allocating resources currently devoted to the overburden construction.
- The results from the cosmic ray task force can be useful for value engineering of the overburden for the near detector.
- The reclaimed shielding blocks should be surveyed for radioactivity within limits acceptable to the collaboration.
- An approach to validate unlisted ASME B31.3 components needs to be agreed upon and accepted by the stakeholders. We encourage that this activity occur as soon as practical.
- The electron lifetime requirement should be verified and the impact of it should be understood by the cryogenic system designers.
- The program should consider having additional independent functional reviews to verify physics and technical requirements at the component level. These reviews can be helpful in pre-empting potential issues with poorly specified requirements and or integration.

Recommendations

1. There should be a unified process for approving design, requirement, and interface documents between institutions. The full SBN collaboration should agree on a process for change control.

2. Recommend a joint CERN-FNAL-INFN meeting to identify and document the scope, resources, and interfaces for the ICARUS installation. Specify the assembly procedure and identify the resources needed for installation as well as who provides them.
3. A formal agreement between CERN-FNAL-INFN covering the delivery and acceptance of the ICARUS detector system should be developed. This should include applicable safety codes and supporting documentation, enumeration and timeline of laboratory reviews and signoffs, and resource allocation for the delivery and operation.

2.2 Detectors

Subcommittee Lead: Mayly Sanchez

Subcommittee Members: Bruce Baller, Melynda Brooks, Gary Drake, Luca Grandi

Charge Questions:

- Have performance requirements been defined that meet the goals of the SBN program?

There was insufficient information presented at this review to answer this charge question for each detector in the program.

- Have independent design reviews been conducted? Based on the design reviews, are the designs sound and likely to meet the performance requirements?

Yes. A preliminary design review of the SBND TPC was performed in September.

- Based on the design reviews, are the designs sound and likely to meet the performance requirements?

Yes, with the caveats noted in the comments and recommendations above.

- Do the designs capture the entire scope and are they adequately defined?

Yes, with the caveats noted in the comments and recommendations above.

- Have the partnering agencies/organizations (e.g. CERN, DOE, INFN, NSF, SNSF, and STFC) identified and agreed to their respective scope?

This aspect of the program was not reviewed within the detector sub-committee.

The detectors sub-committee considered aspects of the design, construction, and installation of the SBND detector as well as refurbishment and installation of the ICARUS detector including design and construction of new detector subsystems such as the cosmic ray tagger and light collection system.

The detector sub-committee was charged to assess (1) whether performance requirements were defined that met the goals of the SBN program (2) have independent reviews been performed (3) are the designs sound and likely to meet those performance requirements (4) do the designs capture the scope and have the partnering agencies identified and agreed to their scope. The committee was asked to specifically focus on aspects of the program that are funded by DOE or that might expand the scope of the funding.

We note that a preliminary technical design review of the SBND TPC detector system was performed in September 28, 2015. The performance requirements were evaluated at this time and were found to meet the physics specification of the program. Many of the performance requirements have been adopted from other detectors without significant modification. It may be worthwhile to spend some time verifying that it is justified to do this in all cases given that the SBND detector is not identical to the systems it was modeled after.

There was no time dedicated in the detector breakout sessions to address the recommendations of the technical design review for SBND and how the issues were being addressed. The committee strongly recommends that the outcome of this review be addressed prior to the start of construction in the form of a final design review.

While a top-down assessment of the schedule was not done at this review, the sub-committee did have concerns that the appropriate interdependencies need to be developed in the SBND schedule and adequate time is allotted for Q/A and appropriate prototype testing before going into production on items. The schedule appears aggressive and we urge the collaborations to perform careful risk assessments and consider whether delay(s) in schedule might allow for significant risk reduction.

We would like to note that there were some commendable collaborative efforts developed between the SBND and ICARUS members in, for instance, the light collection system. The committee encourages the two collaborations to find appropriate venues where they can continue to develop communication channels, share technical knowledge with each other and explore where common solutions and resources can be shared for common problems.

We also like to note that the addition of a cosmic ray tagger to the Far Detector location of the SBN program at the beginning of data taking is very important and we commend the effort on baselining a design and seeking funding to complete it.

SBND TPC Mechanical Construction

Findings

- The detector performance requirements for the SBND TPC are well established, and relate back to the physics specifications according to the conclusions of a preliminary design review conducted on Sept. 28, 2015.
- During the preliminary design review 19 recommendations were made. The status of these recommendations as they relate to the TPC mechanical construction was not provided for this review.
- The SBND team presented their progress on the TPC mechanical construction. The TPC is nearing its final design to begin construction as early as January 2016. The procurement of some items is already in progress. Significant work is ongoing on prototyping elements of the detector as well as procedures.

Comments

- More care is needed in the construction requirements. For example the requirement that “the APAs are constructed in a manner that guarantees no wires will break during the operational life of the experiment” is not achievable.
- The requirement for a maximum electric field of 30 kV/cm within the TPC seems reasonable. Modeling of the electric field in the vicinity of features that could create high field regions should be done. An example is the liquid-gas interface on the TPC G10 hanger rods.

Closeout Presentation

- Two different procedures were presented for winding wires. The UK procedure is non-standard and has yet to be tested. The TPC construction schedule is aggressive, allowing little time for R&D on wire winding procedures.
- The plans for APA cleaning, testing and shipping were not presented. Concepts for these processes were described verbally. Procedures should be written and approved by the project team.
- A prototype of the CPA should be constructed and measurements made to ensure that the required flatness could be achieved. It is possible that the mesh may be looser or tighter at 89K than at 300K.
- The method for attaching the mesh to the CPA frame has the potential for creating numerous local sharp points that could cause HV breakdown.
- The schedule exists at a very high level, with construction beginning in early 2016 and finishing in March 2017. WBS 2.3 consists of 11 tasks spanning a two-year period. Milestones, schedule logic and resource needs were verbally discussed but not presented in sufficient detail. Thus the committee was unable to assess the reliability of the schedule.

Recommendations

4. Develop detailed procedures for APA cleaning, warm and cold testing, transportation and acceptance of all TPC components. These plans should be formalized and documented.
5. Develop a detailed TPC construction schedule that includes milestones, logic and resource needs. The schedule should show a clear linkage and allow time for review of outcomes between the completion of procedure prototyping and the beginning of construction.
6. The SBND team should conduct readiness reviews before beginning major activities, e.g. wire winding, field cage construction, etc. The recommendations of the preliminary design review should be addressed in the context of a final design review, which should take place before construction.

ICARUS Detector

Findings

- The ICARUS team presented a progress report in several aspects related to the detector refurbishment in view of the SBN program. In particular, talks were given in the areas of mechanical TPC refurbishment, revision of electronics and cabling and light collection.
- The ICARUS-T600 is currently at CERN where its cryogenic system is being refurbished. Two new cold vessels, one for each T300, are under production at CERN. The warm vessel design has been completed and ready to move to procurement and construction phase. A new passive thermal insulation will be implemented. Both cold and warm vessels are expected to be ready to be transported to FNAL by October 2016.
- The main TPC structure of each T300 module will remain essentially unaltered. Only the cathode plates will undergo a mechanical treatment meant to mitigate a sagging/bending issue observed during the LNGS run.

- The readout electronics/cabling has undergone a major revision in order to update the design with state-of-the-art technology. The proposed new electronics features a single board integrating both the analogue and digital components (previously separated) and will be housed on new custom-designed signal flanges. A prototype of the new electronics/flange system is presently installed on a small LAr detector at INFN Legnaro for performance evaluation. The results of the test will be used to narrow down the features of the front-end amplifier. The estimated cost for the electronic refurbishing is 1,950k€. For 2016 fiscal year INFN has assigned 530k€. The remaining funds are not currently committed.
- The light collection system has undergone a major revision. The new T600 will be equipped with 360 Hamamatsu R5912-Mod 8" photomultipliers (90 for each TPC). 200 photomultipliers have already been delivered to CERN and 20 of them have undergone a series of dedicated warm and cold tests for their qualification. New divider bases have been fabricated. The requirement for the time-resolution of the light collection system has been set to 1ns. For this purpose each T300 will be equipped with a light calibration system that will distribute light from a source to each PMT.
- A new evaporation facility has been deployed and characterized at CERN. It will be used to coat the PMT photocathodes with the wave shifter needed for converting the scintillation light to a visible range. The evaporation procedure is well developed. The PMT work is already on-going.
- The refurbishment program is running on schedule. The transport of the detectors to FNAL is scheduled for Feb 2017 and the final assembly is scheduled to be completed by July 2017.
- A team at FNAL has been established in order to develop the plans for reception, installation and integration of the ICARUS-T600 at FNAL.

Comments

None

Recommendations

7. The ICARUS collaboration should work closely with the integration team at FNAL as soon as possible to establish requirements for the transportation and installation of the T600 at Fermilab.
8. The ICARUS collaboration should begin working closely with the Fermilab integration team and the Fermilab ES&H organization to prepare for the safety reviews that will be required as part of the operational readiness review, including, but not limited to, electrical safety and grounding.

Cosmic Ray Tagger

Findings

- Mitigation of cosmic ray backgrounds is crucial for the SBN detectors, in order to reduce the potential low energy electromagnetic shower background contamination to electron neutrino interactions.

Closeout Presentation

- A joint taskforce (across the SBN program) has been created in order to define the requirements and implementation of the overburden and a cosmic ray tagger (CRT) system for all SBN detectors.
- The task force will make recommendations based on the physics impact of different levels of overburden. The current funding plan includes overburden for SBND and ICARUS in FY2018. Current building design is not a limitation given the potential overburden being considered. Funding has not yet been identified for MicroBooNE .
- The SBND CRT is being designed and constructed by the Bern group. It is possible that partial funding is available to additionally build the MicroBooNE CRT. Additional funding is required for fabrication of the support structure and installation of the detector modules.
- Partial funding for ICARUS-T600 is approved by the WA104 (1.2 MCHF). Preliminary cost estimates indicate that the required 4π CRT coverage with similar design as SBND would exceed this amount by a factor of 2. This is a potential area of scope for DOE or other funding agency. Staging options and two lower cost alternatives are being considered. Downselect is anticipated in 6 months provided the appropriate resources are available.

Comments

- The committee commends the task force for identifying the primary and secondary performance considerations as well as the potential advantages of common elements in the CRT system within SBN program.

Recommendations

9. The committee recommends with high priority to baseline a design for a complete CRT to be used with the ICARUS detector at the far detector location. It is important that the CRT is ready at the beginning of physics running for this detector. Funds must be identified and prioritized for this to occur.

Light Collection System

Findings

- A light collection system is to be installed into the SBND detector which includes 60 photomultiplier tubes each mounted behind the APA wire planes, for a total of 120 PMTs. The basic requirement for the system is 100 ns timing resolution.
- The trend toward higher PMT coverage in the design is good as it allows triggering at lower energies where the cosmic ray background is more severe.
- The light collection system for the SBND will share the same technology as is used for ICARUS – Hamamatsu R5912 Cryogenic PMTs, coated with a TPB wavelength shifting film with the TPB coating applied onto the glass at CERN. Testing facilities for the PMTs will be shared between SBND and ICARUS as well.

- A support structure design for the PMTs is currently in progress. This support structure will hold the PMTs and allow for the possibility of adding DUNE style light guide bars, should they be considered in the future. The conceptual design presented for mounting the PMT frames to the APA frames is sound and the committee appreciates the flexibility in being able to mount either before or after the detector is moved to the hall.
- A PMT base design is currently in progress.
- There is a desire to share common electronics between SBND and ICARUS, but a final decision on the electronics of choice has yet to be made. Both groups desire at least 12 bit ADC resolution.
- The cold feed-through has yet to be designed.

Comments

- A productive sharing of technology choices and resources has been developed between the SBND and ICARUS collaboration members for the light collection systems. The committee encourages continued collaboration in this endeavor and in other shared subsystems where possible.
- There was some discussion about possible risk of TPB degradation if the PMTs were not properly protected after coating. Proper precautions should be taken to protect against known degradation risks.
- Care should be taken in selecting components for the PMT bases and a failure analysis performed to minimize failures after installation.
- There is no record of requirements document or design reviews for the SBND light collection system. The SBND collaboration should establish requirements for the SBND light collection system, and draft performance specifications for the electronics from them. This is urgently needed, since the design of the electronics (or selection from existing candidates) will begin soon. The system should be reviewed regularly. Milestones and benchmarks need to be established.

Recommendations

None

Electronics/DAQ

Findings

- The electronics specifications for the SBND TPC are well established, and relate back to the physics requirements.
- The SBN TPC electronics had a technical design review (progress review on electronics) on Sept. 28, 2015. Recommendations were made, and the proponents have provided a response.
- The SBND TPC group has elected to incorporate a fair amount of the signal processing electronics inside the cold volume, including pre-amplification, digitization (ADC), and data concentration. The first two are done with custom ASICs, while the data concentration uses a commercial FPGA. Having

the preamps on the detector reduces source capacitance and hence noise. The proponents claim an improvement of a factor of 2 in signal-to-noise by having the ADCs close to the preamps. Taking into account all of the signals needed for I/O by the cold FPGA, there is a net reduction of a factor of ~ 3 in the number of signal feed-thrus needed through the flange by having the FPGA in the cold volume. Each FPGA services 128 front-end channels.

- The development of the cold electronics for the SBND TPC, including two custom ASICs, their carrier boards, and a mezzanine board containing an FPGA, are all being done by one institution. This work is a joint development for SBND and DUNE. The design team consists of 3 ASIC engineers and 2 PhD students. The design team has been working with cold electronics since 2008. Two iterations of each ASIC for the SBND TPC are planned before committing to a production run. The design iterations are planned to be 6 months apart, with the final production submission planned for the end of 2016, approximately one year from now.
- The mechanical arrangement of the front-end boards for the SBND TPC cold electronics contains several connectors, mezzanine boards, piggyback boards, etc. This was noted in the last review. Some progress was made since then to simplify the arrangement of boards, but a fairly high level of interconnect complexity remains.
- The design of the high voltage system for the SBND TPC is for 120 KV, for an operating voltage of 100 KV.
- The DAQ system for the program has been specified, with clear performance requirements defined. As a baseline, SBND will use the MicroBooNE system with a full move to Artdaq, and ICARUS will use their own design. ICARUS is considering the use of the RCE, which is being used by the DUNE 35-ton detector. Several possible upgrade options are being considered. Resources needed for the SBND development have been estimated. Test stand developments for the different subsystems are in progress.

Comments

- The design of the electronics for the SBND TPC appears to meet the performance requirements. Many of the recommendations from the SBND TPC preliminary design review of Sept. 28, 2015, have been incorporated.
- The issue of how much electronics to have in the cold volume of the SBND TPC is a trade-off between reliability and accessibility versus reducing the feed-thru cable plant and associated cables. The electronics team for the SBND TPC has opted for the latter, while ICARUS team has designed for the former. To address concerns, the SBND TPC team has done significant work in evaluating possible failure mechanisms that could cause a loss of data due to an electronic failure inside the cold volume. Tests are ongoing at BNL to study lifetime and failure rates at LAr temperatures. While these steps provide some assurance, the possibility of failures in the cold electronics and the lack of accessibility and serviceability remain a concern in the absence of real experience with the system. Early experience with the DUNE 35-ton detector may be useful, if it comes in time. A failure of the FPGA is a single-point failure that could cause 128 contiguous channels to fail. It was not clear how this would affect the overall performance of the detector. This should be studied by the collaboration.

- The design team for the front-end ASICs and front-end boards for the SBND TPC is competent and capable. That said, the heavy load of designing two custom ASICs, associated cold front-end boards, and complex FPGA firmware on a short timescale by a single institution is a concern. Some sharing of resources and goals with DUNE helps, but the critical near-term deliverable is for SBND. This aspect is at or near the critical path for constructing the detector. Careful management of resources will be necessary to test the different versions of the ASICs, incorporate design changes, and meet submission deadlines, should additional iterations be needed. It is not clear that additional resources from other institutions could help, except possibly with testing the designs, both at the bench and on prototype detector components.
- The management team should consider ways to add resources to the effort, especially for testing the ASICs, to give useful feedback to the designers as part of the design iteration process. Consideration should be given for testing as many chips as possible from a given prototype fabrication cycle, to provide statistics on the performance. It is often useful to have a different group working with the ASICs on the detector than the group doing the design, as a way to incorporate independent evaluation into the design process.
- It appears that further optimization of the mechanical design of the front-end boards for the SBND TPC is possible. The modularity allows the proponents to mix and match different versions of ASICs and FPGAs easily, which is a benefit in the design stage, but comes at a cost of mechanical complexity and abundant use of connectors for the large system deployment. Since connectors are a well-known point of failure, this remains a concern, especially the long-term performance at LAr temperatures, and mechanical failures due to temperature cycling.
- It was not clear from the presentations how much headroom is being incorporated into the design of the high voltage distribution system. The focus was on the high voltage feed-thru, where the headroom is only 20% above the nominal operating value, which seems marginal. Standard practice would be 50-100%. Recent experience with MicroBooNE underscores the difficulty in modeling and predicting breakdown paths in a large system.
- The DAQ group listed the development of Vertical Slice test stands, although no plans, objectives, or goals of this test were presented. The concept of a Vertical Slice test is often used as a precursor to production, and includes detector components, front-end electronics, timing, triggering, etc. in the test. It was not clear if this is planned for SBND, nor how it fits into the production schedule of the various components of the system. Management might consider the virtue of such a test, and how it would fit into the overall production schedule.

Recommendations

10. The ASIC development and testing for the SBND TPC should be tracked carefully by management, since it is at or near the critical path. Technical design reviews by ASIC design experts should be staged prior to each design submission cycle.
11. The design team for the SBND TPC should consider a bottoms-up evaluation of their headroom in the high voltage system, and consider increasing the headroom where possible. This includes the high voltage feed-through, the field cage, cabling, component tolerances, general clearances, etc. A critical analysis would be useful. This aspect should be revisited at the next design review.

2.3 Booster Neutrino Beam Upgrade

Subcommittee Lead: Chris Polly

Findings

- Several options for increasing the flux to the BNB have been explored with two possibilities emerging.
 - Upgrades to the PS to allow either the original horn or the new horn to run at a 10 Hz rep rate to take advantage of NuMI downtime (10% assumption) and beam during the 5s slow spill cycles.
 - 25% increase in event rate relative to current limitation of 5 Hz opportunistic running
 - \$1.5M to allow new horn to operate at 10Hz, \$750k to allow old horn to operate at 10 Hz
 - Re-optimization of the horn geometry to increase the flux with additional focusing
 - 70% increase in event rate
 - \$5M top-down estimate
- The current expectation from program planning allows for 5 Booster batches out of 20 in a MI cycle to be delivered to BNB for a total of $3.8e20$ POT/yr. Running opportunistically at 5Hz in the slow spill and NuMI downtime (10% assumption) increases the POT/yr to $4.0e20$, which is the current capability. Upgrading the PS to run at 10Hz opportunistically increases the POT by 25% to $5.0e20$ POT/yr.
- A two horn scenario as originally proposed for MiniBooNE was eliminated due to the space constraint imposed by the existing target hall.
- A longer horn, up to 3.5, can be installed in the existing target vault but requires the stripline and target to be installed separately in a service module that plugs into the horn.
- A radiation analysis has been completed showing that the existing target vault and blast doors are sufficient for the higher flux.
- The exact spectrum produced by the new horn depends heavily on the shape of the inner conductor.
- Designing the inner conductor for maximum event rate results in a 35% increase in expected event rate in the 0-1 GeV energy range (the region where MiniBooNE observed an excess) and an 80% increase in flux at higher 1-2 GeV neutrino energies.
- The top-down cost estimate for the new horn and service module is \$5M.
- The design is currently at a pre-conceptual stage with the full conceptual design expected by March 2016.

- One of the technical issues still to be understood is how to make the connection between the service module and the horn. Connecting the air cooling for the target, water lines for the horn cooling, striplines for the power, and grounding all has to be done remotely to limit exposure in the hazardous radiation area.
- The cost for spare horns is estimated to be 20-50% higher than the current horn, but that is largely offset due to no longer having to replace the Be target with each horn replacement.
- Stress analysis, heat loads, and fatigue calculations have been complete for the new horn design.
- Heating of the horn is primarily from Joule heating.
- The lifetime of the new horn is expected to be similar to the old horn.
- The top-down estimate for the PS upgrades is \$1.5M to increase cooling to the recovery choke and add 4 new charging supplies.
- The additional charging supplies would not be required to upgrade the old horn to 10 Hz operations.
- The earliest installation opportunity for the new horn would be in the summer shutdown of 2019 and requires the funding profile to ramp up significantly in FY17 to realize that date.
- With funding, the PS upgrades that would also benefit the old horn operations, could be completed at any time.

Comments

- The small team working on methods to increase the flux should be commended for their excellent work to value engineer a number of options for producing more neutrinos.
- The team has done a significant amount of work to optimize a cost effective solution subject to the constraints imposed by the existing target hall.
- The baseline POT/yr without any upgrades is 4.0×10^{20} POT/yr. Assumes 5 Booster batches per MI cycle and 5 Hz opportunistic running during slow spill and NuMI downtimes.
- Overall the design is approaching what would be consider a CDR level design and is expected to be completed by March 2016, although it is based on a large body of horn experience so is more advanced than conceptual in many ways.
- The upgrades fall under two categories:
 - Upgrading the PS to run at 10Hz opportunistically for a 25% increase in flux (assumes 10% NuMI downtime)
 - \$1.5M to upgrade recovery choke cooling and add 4 new charging supplies
 - It was noted that the old horn could also operate at 10 Hz, and would require only the first half of the PS upgrade (recovery choke part) to be completed

Closeout Presentation

- Replacing the old horn with a new longer horn that would increase the event rate by 70% (flux \times xsec) at a cost of \$5M
- The exact spectrum can be shaped by the final choice for inner conductor shapes. The shape that optimizes event rate would increase the event rate in the 0-1 GeV energy range by 35% with an 80% increase in event rate in the 1-2 GeV neutrino energies.
- The design looks feasible and does not depart significantly from other proven horn designs. The cost estimates are top-down but are based on ample experience with similar horns.
- In order to perform the cost/benefit analysis it would be beneficial to understand at what POT the physics analyses start to become systematic limited.
 - MiniBooNE systematics became important at $6e20$ POT, which equates to 18 months of running. This number should be higher with the increased rejection of NC π^0 backgrounds and the error cancellation in the near/far ratio.
 - Increased flux in the 1-2 GeV range creates the possibility for more NC π^0 events to feed down into the signal region. However, the rejection of these backgrounds will be much better in liquid Ar. This merits additional study.
- Under any scenario, the increase in flux would be a welcome addition in running with anti-neutrinos where the pion yield is reduced by ~ 2.5 .
- The earliest opportunity for installation of the new horn would be in the 2019 summer shutdown and would require significant funding to begin in FY17.

Recommendations

12. Complete the conceptual design along with a bottom-up cost estimate, preliminary schedule, and cost profile for further review.
13. Perform simulations to clarify the additional sensitivity reach from the new flux spectrum, quantify at what POT systematics start to dominate, and the dependence on assumptions about NC π^0 rejection and cancellation of errors in the near/far ratio.

3.0 Project Management

3.1 Cost and Schedule

Subcommittee Lead: Rich Marcum

Subcommittee Member: Bill Freeman

Charge Questions:

- Are the DOE cost and schedule estimates credible and realistic?

Yes – We commend the Program for the quality of estimate documentation for the majority of the Program.

- Is the proposed DOE spending profile consistent with the projected available budget?

Yes – Based on cumulative data the spending profile is consistent with the projected budget, but there are concerns with FY17 annual plan and the lack of contingency.

- Has adequate scope and schedule contingency been identified?

No – SBN does have a small amount of budget contingency, approximately 10% for DOE funding. If this were a project a reasonable contingency would be 30 to 40% with schedule contingency of about 12 months.

- Is the overall schedule reasonable and considerate of all stakeholders?

Yes – Although it is difficult to ensure the overall schedule is reasonable due to many MOUs, SOWs, and WPAs being negotiated and in need of further clarification including expectations, deliverable products, and schedules. Despite these difficulties, the SBN Program has considered and planned for the overall needs as far as they are understood at this time.

Findings

- The program has a Work Breakdown Structure (WBS) and associated Organizational Breakdown Structure (OBS) that helps define necessary deliverables and responsibilities.
- SBN Program is using Microsoft Project (MSP) as their scheduling tool.
- The MS Project schedule is organized around the SBN Program's Work Breakdown Structure (WBS).
- The Program has a detailed schedule with 1297 activities that cover most of the program work scope.
- The funding source for each activity is identified using schedule codes.
- Activities associated with the Program's DOE-funded portion of the scope in the MS Project schedule include relationships and resource assignments. Assigned resources include M&S and costed labor.

Closeout Presentation

Resource “flavors” include: electrical and mechanical engineers/designers/drafters, technicians, and computing professionals at both Fermilab and BNL.

- The Program’s non-DOE-funded activities, with relationships, are included in the MS Project file to facilitate progress tracking toward specified completion milestones associated with certain deliverables. Some of these activities are resource-loaded. Other in-kind activities in the schedule are not resource-loaded.
- Scientific labor resources (physicists, post-docs, physics grad students) are not included in the MS Project resource assignments, with one exception (a Los Alamos post-doc resource assigned to several non-DOE tasks).
- Various activity codes are utilized in MS Project to facilitate filtering, sorting and grouping/rollup of activity, resource, budget, and funding source information.
- Fully-burdened and escalated time-phased budgets for the Program’s DOE-funded scope are derived from the MS Project schedule and Cobra. Initial loading of time-phased budget and status information into Cobra has taken place and initial CPR Format 1 reports have been produced.
- The Program can currently evaluate cost and schedule performance.
- The Program’s DOE funding requirements fit within the funding availability in FY15-FY16, but by FY17, the cumulative need is very close to the cumulative DOE funds available, leaving very little management reserve at that point.
- The current schedule is essentially a technically-driven one. No resource-leveling has been applied for analysis of timeline and resource availability.
- The Program stated that they were thinking of using contract labor for some of the cryogenics work to help level the resource load and reduce the need for schedule contingency.
- A conceptual contingency plan has also been considered for moving scope off-program to OPS or shifting the scope to OPS funding, to maintain the budget within R&D funding constraints.
- SBN Program stated that procurement cycle times are accounted for in the durations of design and fabrication activities.
- Critical path analysis has not been performed. However it is understood that the far detector (ICARUS) is the priority.
- One important scientific need, the Cosmic Ray Taggers, are still unplanned and not budgeted.
- Budget estimates are based on past experience with labor, past invoiced materials, or quotes. Many BOEs also identify contingency estimates that range from 10 to 40%. None of the contingency values are included in the budget. Certain contingency information has been added into MS Project, but it has not been used to produce bottoms-up contingency estimates in either MS Project or Cobra.

Comments

- The WBS and OBS seem reasonable and are the foundation for the schedule structure.
- The funding source and other codes in MSP have several errors or inconsistencies.
- The program schedules are aggressive and lack defined schedule or resource contingency. Past schedule performance supports the conclusion that the planned schedule is aggressive with a 0.8 SPI and 1.38 CPI cumulative September through November. The reviewers commend the program for having EV data available. We believe SBN will need 12 months schedule contingency to ensure confidence in its timeline.
- Shifting from FNAL labor to contract labor to reduce the need for schedule contingency is likely to increase the cost. This has not been accounted for in the budget.
- The MSP schedule is incomplete in various areas and needs further review and refinement. A WBS L2 manager stated that the schedule was put together quickly and lacks some relationships needed for a full logically-driven schedule. This was verified by the committee.
- Understanding the project critical path is necessary for making budget and schedule decisions. The program should take advantage of their scheduling capabilities and utilize critical path analysis.
- Budget estimates appear to be reasonable, but based on the program's own identified contingency estimates, the committee questions the reality of meeting cost constraints without a contingency plan.
- BOEs were well prepared and, with the exception of the DOE cryogenics BOEs, it was easy to understand how the estimates were developed. We commend the Program for their development and documentation of their BOEs. We encourage updating the DOE cryogenics BOEs to meet the same standard as other Program BOEs.
- Take advantage of available earned value data as a tool for assessing program health.

Recommendations

14. Scrub and correct schedule for inconsistent or missing information including: Task relationships, erroneous or superfluous tasks, task descriptions, resource assignments, and codes. This should be accomplished by the end of the second quarter of FY16.
15. Develop a contingency plan and obtain agreement with funding sources as appropriate. This should be accomplished by the end of the second quarter of FY16.
16. Ensure that all work scope required to meet the science objectives, including the Cosmic Ray Taggers, is included in the MSP schedule. This should be accomplished by the end of the second quarter of FY16.
17. Perform resource leveling of the MSP schedule and budget profile. This should be accomplished by the end of the second quarter of FY16.

Closeout Presentation

18. SBN program should continue development of overall schedule based on collaboration agreements including signed MOUs, SOWs, and WPAs.

3.2 ESH

Subcommittee Lead: David Mertz

Charge Questions:

- Is ES&H being appropriately addressed?

Yes. Experiment personnel have demonstrated an awareness of environmental, safety, and health requirements in their presentations given in the breakout sessions. The particular hazards associated with liquid argon (LAr) detectors have already been defined by the work on previous LAr detectors as well as methods for successfully mitigating them.

- Are the required environmental approvals, permits, and safety approvals on track to meet the schedule?

Yes. The ES&H permits and approvals process for the facilities to house the SBND and ICARUS detectors is well integrated into the facility construction process at Fermilab and have been completed or on track for timely completion. Permitting for experimental equipment remains to be completed, but nothing in the scope of work appears to be particularly difficult. The technology to be used for the Cosmic Ray Tagger for the far detector has not yet been defined.

Findings

- Facilities and equipment installed at Fermilab must follow the Fermilab Environmental, Safety, and Health Manual (FESHM) requirements and the Work Smart Standards which are part of the contract between the United States Department of Energy (DOE) Fermi Research Associates (FRA). EU institutions are among those participating in the Program. Differences exist between the EU standards and those that must be followed at the Fermilab site.
- Presentations have included brief references to isolated or ungrounded electrical systems and “Detector Grounds.” Under the National Electrical Code and DOE policy, these are only permitted under an equivalency or variance.
- The major detector components are large and heavy.
- The means used to move the ICARUS detector from grade level into position inside the building presents challenges. An extended loading dock inside the building or extending the building crane rails outside the building have been identified as possible means to facilitate moving the detector.

Comments

- The activities to construct and install the detectors and their supporting electrical, electronic, and cryogenic systems will present hazards to the workers. Design systems and plan installations carefully to minimize the hazards to which workers will be exposed and use the Fermilab Hazard Analysis process to identify remaining hazards and to protect workers from them. These hazards are likely to include confined spaces, work at heights, pinch points, electrical, oxygen deficiency, and high and low temperatures.

Closeout Presentation

- The anode plane assemblies use copper-beryllium wires. These anode plane assemblies were described as being delivered to Fermilab as completed assemblies. These assemblies shall be identified on drawings as containing beryllium, and labels shall be placed on the detectors to identify them as containing beryllium. If these wires must be repaired or replaced when at the laboratory, the workers doing so must receive appropriate training on beryllium hazards and safe work practices.
- Plan means of access from the facility floor or grade level to the detector tops and other parts of the detectors that may need to be accessed. Evaluate providing permanent means of access for places where it is reasonably expected that frequent access will be needed during installation and commissioning or where periodic access will be required once detector installation is completed.
- Provide adequate lengths and sufficient support for cables and hoses so that they and their connectors are not placed under unnecessary tension or strain.
- Plan the physical arrangement of electrical equipment, conduit, and cable tray, and of mechanical piping and equipment, to preserve required working spaces, permit ready access to and through electrical and mechanical equipment areas, and offer ergonomically benign working conditions.
- Locate permanent electrical receptacles to eliminate the use of extension cords and power strips (other than rack-mounted power distribution modules) once detector installation is complete, and to facilitate installation and commissioning work as well as periodic servicing or maintenance.
- It is easy to create inadvertent connections between isolated or ungrounded electrical systems or “Detector Grounds” and the regular building grounding system. Carefully plan the electrical isolation between these systems, including structural isolation, such as between detectors and the floors on which they rest, electrical connections, and piping systems. The use of an injected signal alarm system such as was done for MicroBoone may be beneficial for identifying unintended grounds at the time they are created.
- Communicate needs for structural supports, anchor points, wall openings for cables and piping, and other features that could be included during facility construction to Fermilab as the need for them is identified. These features can often be included during site construction at lower cost, with greater robustness, and with less impact to the integrity of the building.

Recommendations

19. Identify where products made to EU standards may not meet the standards that must be followed at the Fermilab site and determine what means will be used to ensure compliance with Fermilab standards.
20. Prepare statements of equivalency or requests for variance for non-solidly-grounded electrical systems well in advance of fabrication and installation of detector electrical systems.
21. Design facilities and large detector components to facilitate installation and servicing of detector components that may pose material handling challenges, paying particular attention to lifting, rigging, working at heights, entrapment, and pinch points.

22. Include features during construction of the SBN far detector facility that will readily accommodate temporary or permanent loading dock or crane rail extensions, or other means that might be identified to facilitate installation of the ICARUS detector.

3.3 Management

Subcommittee Lead: Dan Green

Committee Member: Jim Strait

Charge Questions:

- Have sufficient management plan documents been developed?
Yes
- Are coordinated management teams in place?
Yes, a strong team has recently been put in place.
- Is there a credible plan for interface control?
Yes there is a plan but many improvements need to be implemented in this complex Program.
- Are the projected resources sufficient to complete design, construction, and installation and are these resources likely to be available when needed?
No, there is insufficient contingency and scope and schedule contingency need to be identified and implemented.
- Are critical procurements sufficiently understood and coordinated across the organizations involved?
Yes, but the WPA need to be signed and agreed to so that critical procurements can go ahead in a timely fashion.

Findings

- No science flow-down of requirements to technical specifications was shown at this review.
- The SBN is a Program, not a Project. The program is also complex with contributions from DOE, NSF, Britain, Italy, CERN, Switzerland and Brazil.
- A schedule and WBS was shown and posted to the Committee.
- Examples of the BOE documentation were shown.
- Design reviews have been begun for the SBN Program.
- A WBS and a MS Project Resource Loaded Schedule exists for the DOE portion of the Program
- A tiered set of milestones is in place for the Program.

- The management estimated that there is approximately 10% contingency for the DOE-funded part of the program in the present planning.
- There are common design elements shared by ICARUS and SBND, such as the PMT.
- Points of Contact with the Program for both SBND and ICARUS have been identified.

Comments

- A strong management team has recently been put in place and is functioning well.
- Coordination and cooperation between the 3 detectors and the Program Management seems to be functioning well at the level of those performing the Program tasks.
- Value engineering efforts on the commonality of items for both ICARUS and SBND should be continued.
- The SBN Program should follow up on the successful joint PAC proposal on Trigger, DAQ, zero suppression and data storage in a Program wide data plan to enable timely science.
- A set of science requirements should be enumerated and prioritized. Some idea how the overall SBN Program plans to optimize the physics output of the Program should be developed.
- Given the complexity of the Program, the interfaces, as captured in the WPA should be given priority and perhaps even augmented with intermediate milestones, reporting on percent complete, signatories at hand-off, travelers and whatever test procedures are to be used.
- WPA milestones should be tracked by the Program and progress should also be tracked where possible.
- It is of great importance that regular, timely, and transparent reporting on the status of work to be performed be communicated to Program Coordination in order to assess the progress of the Program.
- It is important to fully develop the agreements in the WPAs to document and agree on responsibilities and interfaces at the level of the people actually doing the work, even if there is no formal sign-off at higher levels. We note, however, that agreements between Fermilab and CERN and between Fermilab and INFN do need to be pursued on a formal basis so as to insure timely procurements.
- Even though SBN is not a Project, nevertheless many of the tools of Project Management would be of great use to the SBN Program.
- The DOE contingency presented of ~10% is insufficient to cover the risks to the Program. The Program should make a careful risk assessment and then plan accordingly. The host lab in particular needs sufficient contingency to cover installation and commissioning problems. For a program of this scope and complexity, one would expect a bare minimum of 30% contingency at this stage.
- The SBND schedule has no float since it is presently technically limited. A reasonable assessment of schedule risk might be 12 months of schedule float.

Closeout Presentation

- The critical path should be identified and tracked in order to enable management to respond accordingly as the path evolves. Although this program is not bound by 413 type milestones for its completion, time is of the essence for the physics. Fermilab needs to provide the resources necessary to support the timely completion of the design and construction, particularly for the infrastructure to support the far detector.
- A plan must be put into place to enable the start of installation of a full ICARUS cosmic veto in coordination with the rest of the detector installation. The CRT design needs to be adequately conservative unless and until the spread in physics modeling is reduced. The joint CRT task force is a very positive development. Other technical decisions should be approached in a similar fashion.
- The Program should attempt to secure funding in order to cover schedule risks.
- Consider forming a “Technical Coordination Group” comprising the Program Coordinator, the Technical Coordinators of the three individual programs (ICARUS, SBND, and Infrastructure and Integration), and perhaps a few other technical experts if appropriate. That group would track the WPA progress, meet regularly and set priorities for installation and commissioning of the overall Program, track progress with respect to the milestones, and solve technical and coordination problems. There could be economies of scale across the 3 detectors. There should be some synergy with LBNF/DUNE research. Fungible resources should be employed for an overall optimization of resources across the Program.

Recommendations

23. Address the cosmic ray taggers for the 3 detectors in a timely fashion.
24. The MoU and associated WPA are critical to the success of the program. They should be vigorously pursued so that timely procurements can be made and that commitments can be finalized as soon as possible. The Program Office should track the WPA tasks.

4.0 Appendices

- A. Charge
- B. Agenda
- C. Review Committee Contact List and Writing Assignments

Appendix A
Charge
Director's Progress Review of SBN
December 15-17, 2015

28-Oct-2015

To: Mike Lindgren, Chief Project Officer
From: Nigel Lockyer, Director
Subject: Director's Progress Review of the Short Baseline Neutrino Program

Please organize and conduct a Director's Review on December 15-17, 2015 to assess the progress to date and plans for execution of the Short Baseline Neutrino Program. This review should cover the following aspects of the program:

- Design, construction, and installation of the SBND detector;
- Refurbishment and installation of the ICARUS detector including design and construction of any new detector subsystems such as the Cosmic Ray Tagger;
- Design, construction, and installation of the necessary support infrastructure such as buildings, cryogenic systems, overburden and DAQ;
- Progress toward a conceptual design for upgrades to the Booster Neutrino Beam (BNB).

The focus of this review is cost, schedule, management, ES&H, and technical readiness for the execution of the program. The review committee should respond to the following questions:

1. **Design and Scope.** Have performance requirements been defined that meet the goals of the SBN program? Have independent design reviews been conducted? Based on the design reviews, are the designs sound and likely to meet the performance requirements? Do the designs capture the entire scope and are they adequately defined? Have the partnering agencies/organizations (e.g. CERN, DOE, INFN, NSF, SNSF, and STFC) identified and agreed to their respective scope?
2. **Cost and Schedule.** Are the DOE cost and schedule estimates credible and realistic? Is the proposed DOE spending profile consistent with the projected available budget? Has adequate scope and schedule contingency been identified?
3. **Management.** Have sufficient management plan documents been developed? Are coordinated management teams in place? Is there a credible plan for interface control? Are the projected resources sufficient to complete design, construction, and installation and are these resources likely to be available when needed? Are critical procurements sufficiently understood and coordinated across the organizations involved?
4. **Environment, Safety, and Health.** Is ES&H being appropriately addressed? Are the required environmental approvals, permits, and safety approvals on track to meet the schedule?

The committee is asked to present a draft of their report at the review closeout and to issue the final report within two weeks of the review's conclusion.



Nigel Lockyer
Director
Fermi National Accelerator Laboratory

cc:

G. Bock	E. Gottschalk	O. Palamara	P. Wilson
S. Brice	J. Lykken	R. Rameika	G. Zeller
S. Centro	D. MacFarlane	C. Rubbia	
B. Fleming	S. Nagaitsev	D. Schmitz	

Appendix B

Agenda

Director's Progress Review of Short Baseline Neutrino Program
December 15-17, 2015

ReadyTalk Information for Plenaries and Closeout Session:
Toll-Free Dial-In: 866-740-1260; Access Code: 5571684#

Tuesday, December 15

EXECUTIVE SESSION – Comitium (WH2SE)

8:00 – 8:30 AM 30 Executive Session

PLENARY SESSION – One West (WH1W)

8:30 – 8:40	AM	10	Welcome and the Fermilab Context	
8:40 – 9:30	AM	50	SBN Program Overview	Nigel Lockyer
9:30 – 10:10	AM	40	ICARUS T600 Detector	Peter Wilson
				Claudio Montanari

10:10 – 10:40 AM 30 BREAK – Outside One West

10:40 – 11:20	AM	40	SBND Detector	Ting Miao
11:20 – 12:00	AM	40	SBN Facility Infrastructure	Cat James

12:00 – 1:00 PM 60 LUNCH – 2nd Floor Crossover

1:00 – 1:40	PM	40	Booster Neutrino Beam Improvements – One West	Zarko Pavlovic
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PARALLEL BREAKOUT SESSIONS

1:45 – 3:30 PM 135

B01: Detectors – Snake Pit (WH2NE)
B02: Facility Infrastructure – Black Hole (WH2NW)
B03: Management – Comitium (WH2SE)

3:30 – 4:00 PM 30 BREAK – Outside Comitium

4:00 – 5:00	PM	60	Breakouts Continued	
5:00 – 5:30	PM	30	Subcommittee Executive Sessions – in Breakout Rooms	
5:30 – 6:30	PM	60	Executive Session – Comitium (WH2SE)	
6:30	PM		Adjourn	

Wednesday, December 16

8:00 – 10:00	AM	120	Joint Session on Integration and Installation – Curia II	
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10:00 – 10:30 AM 30 BREAK – Outside Comitium (WH2SE)

PARALLEL BREAKOUT SESSIONS – continued in same rooms

10:30 – 12:30	AM	120		
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12:30 – 1:30 PM 60 LUNCH – 15th Floor Crossover (WH15XO)

Closeout Presentation

1:30 – 2:30	PM	60	Responses to Day 1 Questions – Comitium (WH2SE)
2:30 – 3:30	PM	60	Subcommittee – Executive Sessions
3:30 – 3:45	PM	15	BREAK – Outside Comitium (WH2SE)
3:45 – 5:30	PM	135	Full Committee Executive Session - Comitium
5:30 – 6:00	PM	30	Final questions for Program Management and Systems
6:00	PM		Adjourn

Thursday, December 17

8:00 – 10:00	AM	120	Executive Committee Report Writing – Comitium (WH2SE)
10:00 – 10:20	AM	20	BREAK – Outside Comitium
10:20 – 1:00	AM	60	Full Committee Executive Session Dry Run & Lunch
1:00 – 2:00	PM	60	Summary and Closeout – One West (WH1W)
2:00	PM		Adjourn

Table 1
Subcommittee Breakout Session Available Talks

Detector Breakout Session 1 (Tues Afternoon)

- SBND TPC Construction – Kostas Mavrokoridis
- SBND TPC Readout Electronics – Hucheng Chen
- SBND PMT System – Richard Van De Water

Detector Breakout Session 2 (Tues Afternoon)

- Joint Cosmic Task Force – Bob Wilson
- SBND Cosmic Ray Tagger - Igor Kreslo

Joint Detector - Facility Infrastructure Breakout Session 3 (Wed Morning)

- SBND Integration and Installation Planning – Joe Howell
- Far Detector Integration and Installation Planning – Andy Stefanik
- SBN Grounding – Linda Bagby

Detector Breakout Session 4 (Wed Morning)

- ICARUS TPC Readout Electronics – Sandro Centro
- ICARUS PMT System – Gianluca Raselli
- Joint DAQ summary – Wes Ketchum
- SBND DAQ – Eric Church

Facility Infrastructure Breakout Session 1 (Tues Afternoon)

- Civil Construction for Near and Far Detector – Steve Dixon
- Overburden Plan – Jim Kilmer
- SBN Cryogenics: Requirements – Barry Norris
- SBN Cryogenics: Design, Procurement and Installation – Michael Geynisman

Facility Infrastructure Breakout Session 2 (Tues Afternoon)

- SBN Cryogenics: Planning for Safety – Michael Geynisman
- SBN Cryogenics: Schedule and Resources – Michael Dinnon

Facility Infrastructure Breakout Session 4 (Wed Morning)

- SBND Cryostat – Dimitar Mladenov
- T600 Cryostat – Marzio Nessi

Management Breakout Session 1 (Tues Afternoon)

- Program Coordination Details – Peter Wilson

Management Breakout Session 2 (Tues Afternoon)

- SBND Cost and Schedule – Ting Miao
- Facility Cost and Schedule – Cat James

Appendix C

Review Committee Contact List and Writing Assignments

Director's Progress Review of SBN

December 15-17, 2015

Chairperson

Jim Strait, FNAL	strait@fnal.gov	630-840-2826
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Project Management

Dan Green, FNAL Emeritus*	dgreen@fnal.gov	630-840-3104
Jim Strait, FNAL	strait@fnal.gov	630-840-2826

Cost and Schedule

Rich Marcum, FNAL*	rmarcum@fnal.gov	630-840-8236
Bill Freeman, FNAL	wfree@fnal.gov	630-840-3020

ESH&O

David Mertz, FNAL*	mertz@fnal.gov	630-840-6322
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Facilities and Infrastructure

Jim Grudzinski, ANL*	jig@anl.gov	630-252-0195
Mark Messier, IN University	messier@indiana.edu	812-855-0236
Brian Rebel, FNAL	brebel@fnal.gov	630-840-8226
Bill Soyars, FNAL	soyars@fnal.gov	630-840-3362

Detectors

Mayly Sanchez, Iowa State*	mayly@iastate.edu	515-294-4739
Bruce Baller, FNAL	baller@fnal.gov	630-840-2427
Melynda Brooks, LANL	mbrooks@lanl.gov	505-667-6909
Gary Drake, ANL	drake@anl.gov	630-252-1568
Luca Grandi, Univ of Chicago	lgrandi@uchicago.edu	773-834-7659

Booster Neutrino Beam Upgrade

Chris Polly, FNAL*	polly@fnal.gov	630-840-2552
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*Lead

Observers

Adam Bihary, DOE-FSO
Antonio Ereditato, University of Bern
Alan Harris, DOE-FSO
Antonio Masiero, INFN
Stephen Pordes, FNAL LBNC Member
Eli Rosenberg, DOE Consultant